

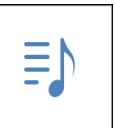


Armed Forces College of Medicine AFCM





**Heat production
regulation
&
Mechanism of fever
By
Mona Gamal El-Din Al
Anan**



INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

1. Describe the mechanisms by which heat is produced in and lost from the body
2. List the body temperature that is recorded from rectum, oral cavity, and skin
3. Explain the mechanisms by which the body temperature is regulated
4. Explain the pathophysiology of fever



The body can be divided into two regions :

a- The Core (contents of the skull, thorax & abdomen)

b- The shell (includes the skin, subcutaneous tissues & the limbs)

Core temp. is relatively constant

Shell temp. is variable according to



Normal Body Temp.



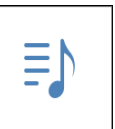
The normal body temperature is different from individual to individual, the average in young adult:

Orally: $36.3^{\circ}\text{C} : 37.1^{\circ}\text{C}$ “ $97.3-98.8^{\circ}\text{F}$ ” (affected by: Food ingestion, gum chewing, and mouth breathing)

Rectally: $\approx 0.5^{\circ}\text{C}$ more than oral temp.

N.B.:

The rectal temperature is representative of the temperature at the core of the body and varies least with changes in environmental temperature



Variation in body temp.



1- Diurnal rhythm : circadian fluctuation

(It is lowest in the early morning & rises to maximum in the early evening due to change in MR)

2- Sever exercise □ During exercise, the heat

produced by muscular contraction

accumulates in the body and the rectal

temperature normally rises as high as 40 °C

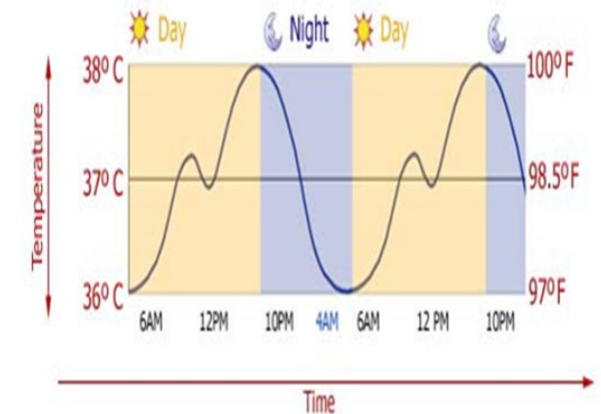
(104 °F), due in part to the inability of the heat-dissipating mechanisms to handle the greatly increased

amount of heat produced.

New Five Year Program

GIT and Metabolism Mona Gamal

Circadian Rhythm (Body-Temperature Cycle)



<https://nikdchposmatreh6cd6.kinstacdn.com/wp-content/uploads/2018/09/body-temperature-throughout-the-day.png>



Variation in body temp.



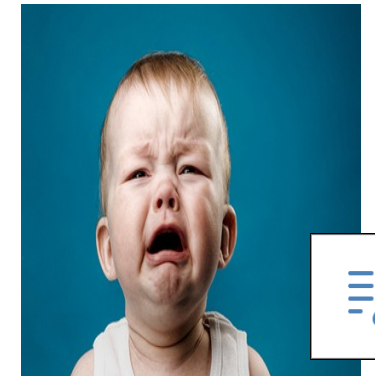
3 - Sex: In females the body temp. rises by 0.5 in the second half of menstrual period “due to thermogenic effect of progesterone”



4 - Emotions: increase body temp. “due to sympathetic activity & unconscious tensing of the muscles”



5- Age: Temperature regulation is less precise in young children and they may normally have a temperature that is 0.5 ° or so above the established norm for adults



Variation in body temp

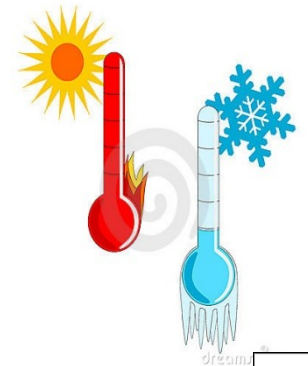


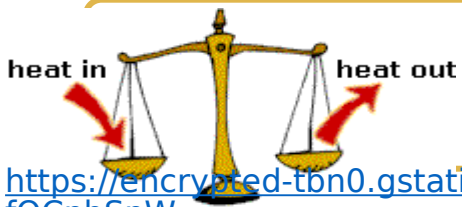
6 - Individual variation: Some persons have temp. higher than the normal range (constitutional hyperthermia)

7 - Endocrine factor: It is chronically elevated $\approx 0.5^{\circ}\text{C}$ when the metabolic rate is increased, e.g. hyperthyroidism, and lowered when the metabolic rate is low, as in hypothyroidism



8 - Environmental temp.: Body temp. increases in hot weather and decreases in cold





Heat Balance



$$\text{Heat gain} = \text{Heat loss}$$

WHY ???? Because the balance between heat production and heat loss determines the body temperature, that must be relatively constant for normal body functions

WHY ??? Because the temperature alters the speed of chemical reactions since the body's enzyme systems have optimum temperature for function

SO, a group of reflex responses that are primarily integrated in the hypothalamus, operate to maintain body temperature within a narrow range in spite of wide fluctuations in environmental temperature



Heat Balance



The main factors that lead to **heat production (gain)** are:

1- Muscular exercise

2- All the vital processes that contribute to the basal metabolic rate

3 - Endocrine factors like:-

* Thyroxin (slow prolonged effect)

* Epinephrine and norepinephrine (rapid and short effect).

4- External environment : sun rays ↑ temp. leads to increase of chemical activity of all cells)

5- Food intake: Assimilation of food (SDA thermal effect of food)

6- Brown fat: Special type of fat only in infants with high rate of metabolism and richly supplied by sympathetic nervous system



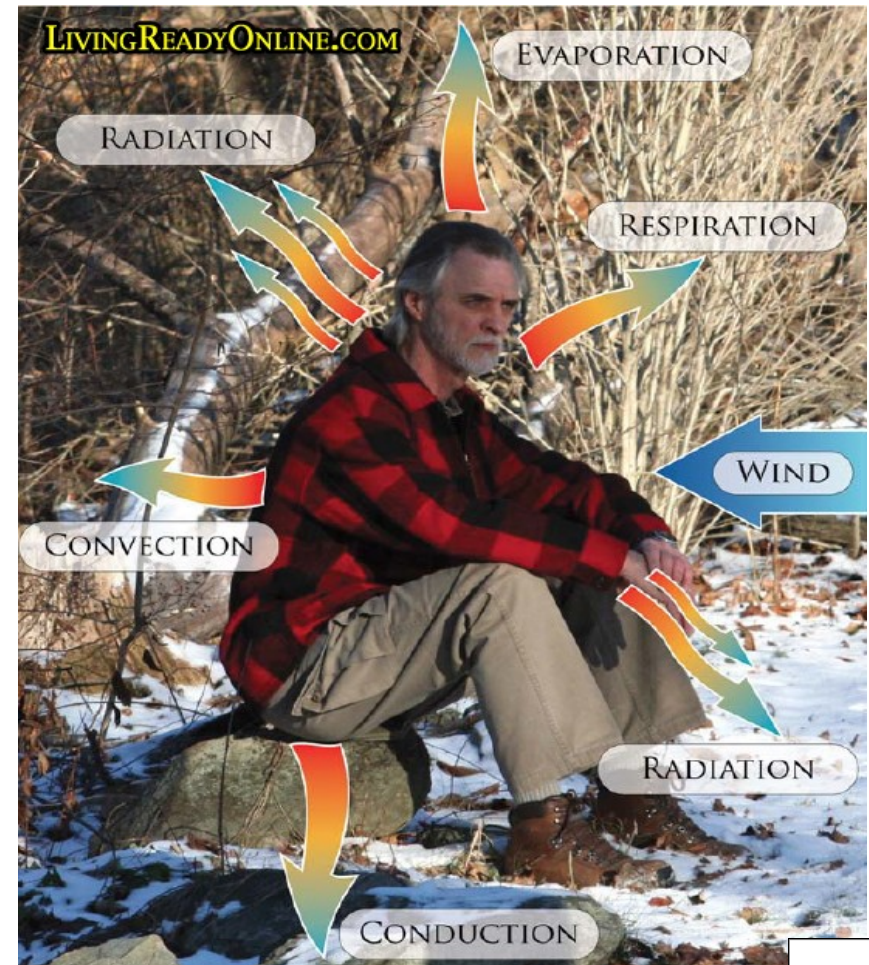
Ways of heat loss



- ❖1- Conduction
- ❖2- Convection
- ❖3- Radiation
- ❖4- Evaporation

The heat is lost from the body by:

Radiation, conduction, and vaporization of water in the respiratory passages and on the skin. Small amounts of heat are also removed in the urine and feces



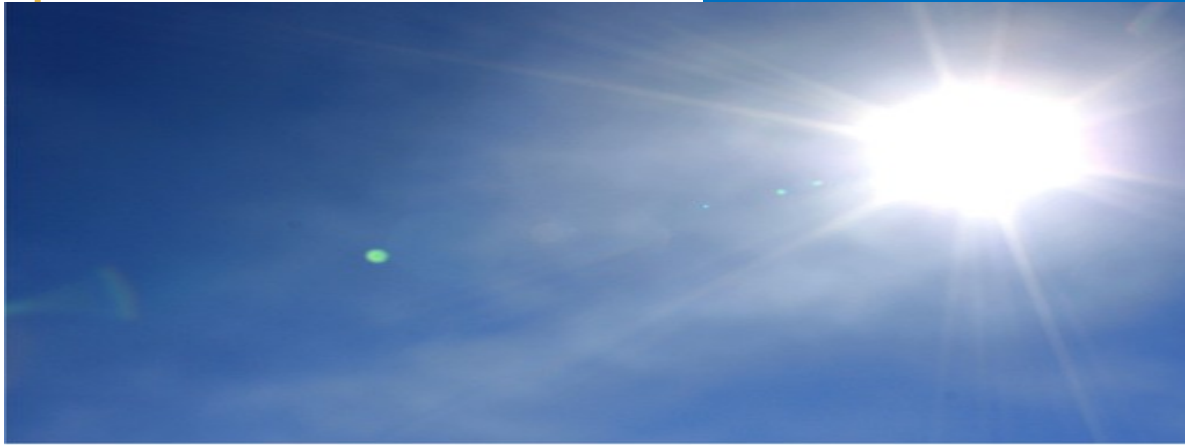
Heat loss



N.B.: Conduction is greater in presence of air currents and greatest in the presence of water

N.B.: If the temperature of air adjacent to the skin rises and becomes equal to skin temperature it forms an insulator zone preventing further heat loss

Ways of heat loss



(a) Radiation



(b) Evaporation



(c) Convection



(d) Conduction

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Heat loss



Environmental temp. must be less than body to have heat loss by radiation

The greater the thermal gradient the more will be the amount of radiation

In comfortable zone (24: 34°C) temperature, 70% of heat loss “radiation, conduction, convection”

and 30 % “evaporation”

If the surrounding temp. is greater than that of the skin, “sweating” only mechanism for heat loss

At 21 °C, “vaporization” is a minor component in humans at rest

As the environmental temperature approaches body temperature, radiation losses *decline* and vaporization losses *increase*

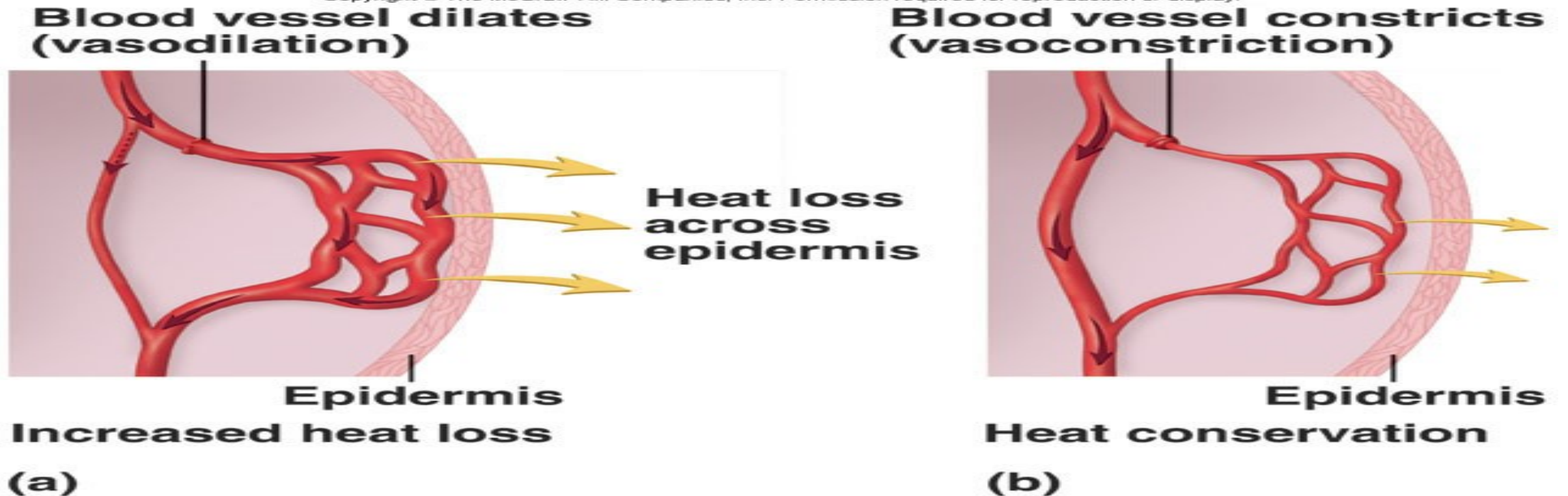


Heat Loss



- ❖ Most of heat production in the body is liberated in the deep organs then lostthe skin & then to air via blood

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Evaporation



Water evaporation from body occurs in two forms

Energy varies from 30 to over 900 kcal/h

Insensible perspiration

From the skin and lungs ≈ 50 mL/h in humans

Sweating

- ❖ From sweat glands
- ❖ Regulated by SNS
- ❖ Humidity $1/\alpha$ the sweat evaporation

Panting in animals have no sweat glands

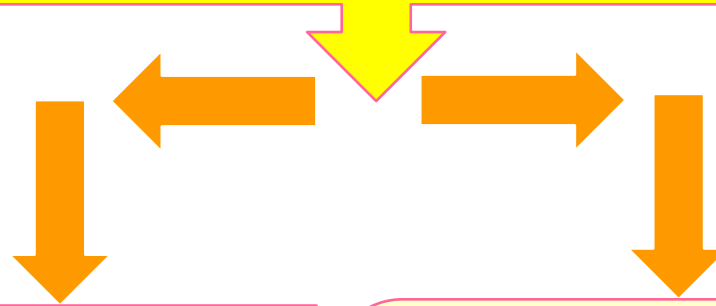
Vaporization of 1 g of water removes about 0.6 kcal of heat



Sweat secretion



Mechanism of sweat secretion



Primary secretion

From the deep subdermal secretory portion of the sweat gland, similar to plasma without plasma proteins (water, Na^+ , Cl^- , K^+ , urea, lactic acid)

Secondary secretion

By the duct, modified primary secretion mainly by reabsorption of Na^+ and H_2O .

Its concentration depends on the rate of sweating

Mechanism of secretion

Types of sweat glands

Acclimatization of sweat secretion

Effect of aldosterone hormone





The slides from 18 to 32 is part B in the same lecture

On exposure to cold, decreasing heat loss is by.....

- 1) Cutaneous vasoconstriction.
- 2) Cutaneous vasodilation.
- 3) decreasing muscle activity.
- 4) decreasing appetite.

Heat-loss mechanisms do not include.....

- 1) reducing activity
- 2) the evaporation of sweat
- 3) behavior measures such as wearing light, loose clothing
- 4) vasoconstriction of peripheral blood vessels
- 5) vasodilation of peripheral blood vessels

Heat-loss mechanisms do not include.....

- 1) reducing activity
- 2) the evaporation of sweat
- 3) behavior measures such as wearing light, loose clothing
- 4) vasoconstriction of peripheral blood vessels
- 5) vasodilation of peripheral blood vessels

Summary & Lecture Quiz



Q. 1 On exposure to a cold weather, one of the major means of increasing heat production is.....

- a) skin vasoconstriction
- b) wearing warm clothing
- c) increased muscle activity

Q. 2 If the surrounding temperature is greater than that of the skin, the only mechanism for heat loss will be.....

- a) Sweating
- b) Radiation
- c) Conduction
- D. convection.

Q. 3 the set point of body temperature regulation in feverished person is which of the following?

- b) Is the same of normal person
- b) elevated than in the normal perso
- c) Lower than in the normal person

SUGGESTED TEXTBOOKS



1. Ganong's "Review of Medical Physiology", 25th edition, chapter 17, Section III, pages 319-320
2. Guyton and Hall "Textbook of Medical Physiology", 11th edition, chapter 72, pages 867-880
3. Sembulingam "Essentials of Medical Physiology", 6th edition, chapter 63, Section 5, pages 359-364 & Chapter 130, pages 746-748



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